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(10) Steven M. Medlin



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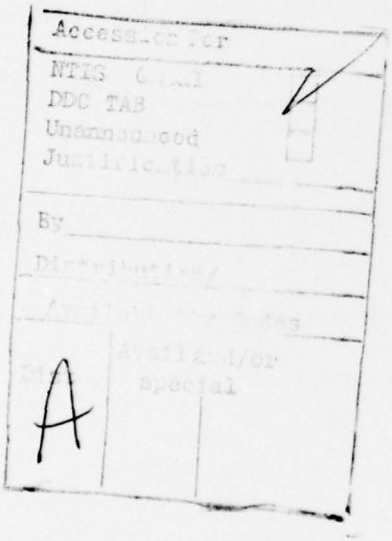


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The Army Research Institute has been involved in a systematic program of research on unit evaluation. The goal of this research is to develop a criterion-referenced system for evaluation of unit tactical performance. A model for an evaluation system is developed using the current ARTEP evaluation system as a starting point. The model also provides (a) a realistic simulated combat environment, in which units perform tactical operations and objective

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performance data can be obtained; (b) procedures for defining standards against which unit performance can be compared; and (c) techniques by which training deficiencies and training level/combat readiness can be assessed.

A review of the current status of the COTEAM evaluation system indicates that research is being conducted on all aspects of the model: (a) The ARTEP manual is being modified to provide empirically determined behavioral objectives, a list of training diagnostic behaviors, objective standards, and a program of instruction for ARTEP evaluators. (b) The COTEAM simulated combat environment exercises are superior to ARTEP field exercises in promoting tactical proficiency, terrain appreciation, and use of cover and concealment; in providing immediate, valid feedback to individuals and weapon systems; in enhancing troop motivation; and in allowing ample opportunity for collection of objective data on unit performance. (c) A set of systematic methods for defining specific performance criteria against which unit performance can be compared are being developed, validated, and implemented. (d) A comparison process, in which behaviors observed in field exercises are compared to performance criteria, is being explored. This comparison subsystem allows for decisions concerning the training level/combat readiness of the unit being evaluated.

**Technical Report 393**

# COMBAT OPERATIONS TRAINING EFFECTIVENESS ANALYSIS MODEL: 1979 PERSPECTIVE

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Training and Education

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## FOREWORD

The model presented in this paper was developed under the Training and Education Project in the Engagement Simulation Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI). The goal of this project was to provide quantitative methods for evaluating unit proficiency. The means for achieving this goal included basic research in criterion-referenced test methodology, measurement and scaling models, and decisionmaking implications of test score interpretation.

The Combat Operations Training Effectiveness Analysis Model (COTEAM) is a criterion-referenced evaluation system based on the Army Training and Evaluation Program (ARTEP). The model integrates aspects of all parts of the Technical Area work program: evaluation of small combat units in a simulated combat environment (ARTEP, REALTRAIN), ARTEP evaluator training, methods for developing performance criteria, and improved training-diagnostic feedback procedures. Research from all of these areas is related to the COTEAM framework.

Anticipated future research under the Training and Education Project includes the development of a computer model for performance evaluation and development of measurement, scaling, scoring, decisionmaking, and quality-control models for use in performance evaluations when criterion-referenced testing procedures are employed.

ARI research in this area is conducted as an in-house research effort. The research program is responsive to the requirements of Army Project 2Q762722A764.

JOSEPH ZEIDNER
Technical Director

COMBAT OPERATIONS TRAINING EFFECTIVENESS ANALYSIS MODEL:
1979 PERSPECTIVE

## BRIEF

Requirement:

To present the current status of theory and research relevant to the Combat Operations Training Effectiveness Analysis Model (COTEAM), an evaluation system for small combat units.

Description of the Model:

The current Army Training and Evaluation Program, ARTEP, possesses several weaknesses. COTEAM is based on the ARTEP framework but corrects its shortcomings by providing (a) a realistic simulated combat environment in which units perform tactical operations and objective data can be obtained, (b) procedures for defining standards against which unit performance can be compared, and (c) techniques for assessing training deficiencies and levels of training or combat readiness.

Findings:

A review of the current status of the COTEAM evaluation system indicates that research is being conducted on all aspects of the model: (a) The ARTEP manual is being modified to provide empirically determined behavioral objectives, a list of training diagnostic behaviors, objective standards, and a program of instruction for ARTEP evaluators. (b) The COTEAM simulated combat environment exercises are superior to ARTEP field exercises in promoting tactical proficiency, terrain appreciation, and use of cover and concealment; in providing immediate, valid feedback to individuals and weapon systems; in enhancing troop motivation; and in allowing ample opportunity for collection of objective data on unit performance. (c) A set of systematic methods for defining specific performance criteria against which unit performance can be compared are being developed, validated, and implemented. (d) A comparison process, in which behaviors observed in field exercises are compared to performance criteria, is being explored. This comparison subsystem allows decisions to be made concerning the training level and combat readiness of the unit being evaluated.

Utilization of Findings:

The findings of this presentation are being used to further refine the evaluation system to be implemented in the Army and to foster further research in the assessment of unit performance in field exercises.

COMBAT OPERATIONS TRAINING EFFECTIVENESS ANALYSIS MODEL:
1979 PERSPECTIVE

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# COMBAT OPERATIONS TRAINING EFFECTIVENESS ANALYSIS MODEL: 1979 PERSPECTIVE

## INTRODUCTION

In recent years, the Army Research Institute for the Behavioral and Social Sciences (ARI) has been involved in a systematic program of research on unit evaluation. The goal of the research is to develop a criterion-referenced system for evaluation of unit tactical performance. Considerable progress has been made in developing evaluation systems that provide (a) a realistic simulated combat environment in which units perform tactical operations and in which objective performance data can be obtained, (b) procedures for defining standards against which unit performance can be compared, and (c) techniques for assessing training deficiencies and training/combat level readiness. One of the current models, the Combat Operations Training Effectiveness Analysis Model (COTEAM), uses the current Army evaluation system--the Army Training and Evaluation Program (ARTEP)--as a starting point but also includes the aforementioned critical features.[1]

As currently used, the ARTEP includes an ARTEP manual, a field exercise evaluation, and a training program based on the evaluation. Figure 1 presents a flow chart of the system. As the figure suggests, the ARTEP manual drives the evaluation system. Based on doctrine and military expertise, the ARTEP manual was designed to be a training and evaluation guide. Evaluation requirements are stated in terms of specific unit performance objectives and focus on whether a unit can perform specified missions. Task statements are written at an integrated, functional, mission-oriented level. Conditions for performing each task have been specified to allow greater standardization of the evaluation. Training and evaluation standards provide a relatively objective basis on which the evaluator can judge the unit's performance on a particular task; the standards also can be used to develop training programs.

The external conditions are factors that influence the ARTEP field exercise and that can be controlled by the evaluator. The ARTEP manual and doctrine determine mission, posture, personnel, weapons, ammunition, and petroleum, oils, and lubricants (POL). The evaluation team determines whether the terrain and weather are suitable, and the time of day

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[1]This model was originally outlined by Eugene Johnson, K. I. Epstein, and Angelo Mirabella as part of ARI basic research on criterion-referenced evaluation. Its features have been described in Epstein and Johnson, 1976, and Mirabella, 1977. Related evaluation concepts have been discussed in Erwin, 1976; Root, Knerr, Severino, and Word, 1978; Sulzen (undated draft report), Sulzen and Root, 1976; and Sulzen, Root, and Epstein, 1976.

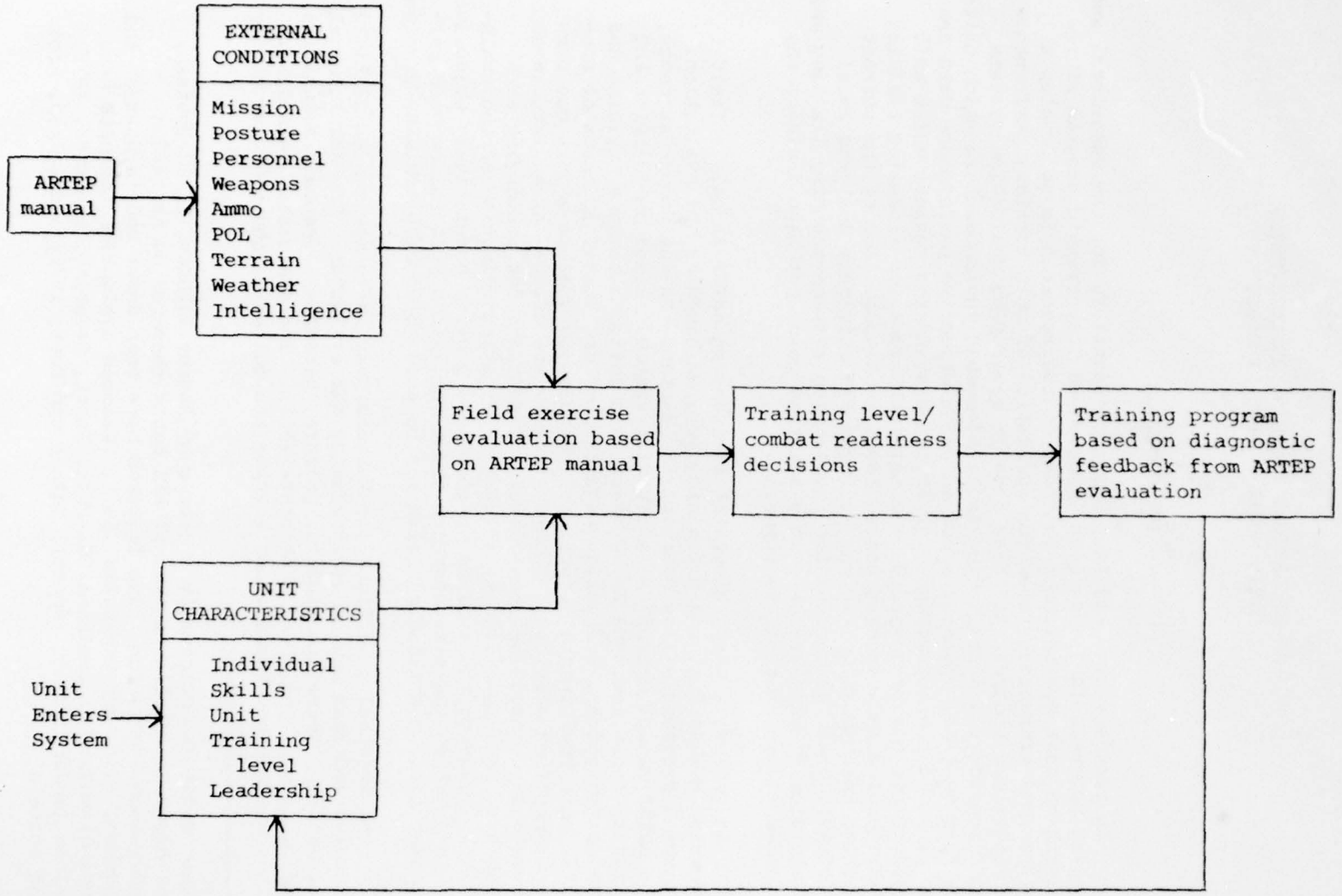


Figure 1. ARTEP evaluation system.

and intelligence for the exercise. (These are examples of external conditions, not an exhaustive list.)

After considering the external conditions, the evaluation team designs a field exercise based on the unit performance objectives in the ARTEP manual. Many characteristics of the unit being evaluated affect its performance in the field exercise; for example, the individual skills of the unit's members, the unit's training level, and the unit's leadership. During the field exercise, the evaluation team uses the ARTEP manual as a guide in the evaluation process. Based on the unit's performance in the field exercise, the evaluation team makes decisions on training level/combat readiness and training remediation. A training program then is designed to strengthen the unit's deficiencies and maintain its proficiencies. As Figure 1 shows, this training program primarily affects the characteristics of the unit, which in turn affect the unit's performance in its next field exercise.

The ARTEP has several major weaknesses that make an improved combat evaluation system necessary. The first weakness lies in the lack of standardized or scientific procedures for determining the tasks, subtasks, and standards in the Training and Evaluation Outlines (T&EOs) of the ARTEP manuals. The current content of the T&EOs was chosen by military experts without the benefit of available procedures for insuring consensus among different teams of experts.

The second major weakness in current ARTEP use is that the field exercises are often unrealistic and do not provide objective data for the evaluation team. If the field exercises do not provide a realistic combat environment, then the evaluation of combat units in this setting has little or no validity.

Third, the ARTEP manual provides little or no guidance to evaluators on how to design exercises, measure unit performance, determine training proficiencies/deficiencies, or evaluate the observed performance. Effective and efficient measurement methodology is lacking, particularly with regard to objective measures of performance and optimal utilization of limited evaluation personnel and equipment. Current practice relies heavily on subjective evaluations and the ability of the evaluation team to anticipate critical events during an exercise and to insure that those events are observed. At best, such evaluation yields good qualitative judgments, but there is no assurance that the judgments will not be more or less arbitrary.

The ARTEP is currently dominated by unsystematized, unaided, idiosyncratic human judgments. The standards tend to be open to considerable interpretation. The complexities of combat are too great to be handled by an evaluation system based solely on an intuitive, subjective, ascientific approach. Although human judgment must play a significant role in the evaluation process, it must be systematized, aided by information-processing technology, and made less idiosyncratic. The lack of objective data and an explicit criterion data base make it

difficult to interpret the results of an evaluation, to compare different units, or to compare the same unit at different times or locations. The evaluation system needs to be driven by objective, quantitative data. Systematized, aided human judgment should be supported by quantitative measures as much as possible. Because of the complex nature of field exercises, the system should incorporate multiple measures at several levels of resolution.

The fourth weakness in current ARTEP use is the lack of guidance on how users are to deal with the partially stochastic nature of combat. Estimates must be made of the degree to which chance events reduce the accuracy of effectiveness measures and therefore reduce the validity of the evaluation decisions. Low empirical correlations between variables that would be expected to be highly related on logical grounds can occur for many reasons. Such reasons include stochastic effects, uniquely effective or ineffective behavior by the opposing team, nontraining sources of variance that may mask learning effects, and the suppressor variable effects of events that intervene between a process and a later outcome. This suggests that the evaluation system should consider the processes leading up to the final outcomes, as well as the final outcomes.

Finally, the ARTEP does not provide guidance in how to develop training programs from the field exercise evaluation. Although the ARTEP is a training and evaluation guide, units typically train to prepare for taking an ARTEP evaluation, or test. After an ARTEP exercise, feedback to the unit is provided, but the feedback is neither timely enough nor in a form that is useful for developing a training program. Furthermore, many aspects of lower echelon performance are neglected during the larger ARTEP field exercises; this violates the ARTEP concept of multi-echelon training and evaluation and prevents the integration of pertinent information from lower echelons into the training program. Thus, critical aspects of training within the ARTEP are lost (Havron & Wanschura, 1979).

## COTEAM

The COTEAM evaluation system uses the ARTEP as a starting point and systematically addresses the ARTEP's weaknesses. Figure 2 presents a flow chart of COTEAM. A comparison of Figures 1 and 2 shows that COTEAM is based on the ARTEP evaluation system. The model modifies the current ARTEP manual and adds these main components: (a) an engagement simulation field exercise test bed, (b) the expected values subsystem, and (c) a comparison subsystem for training diagnosis.

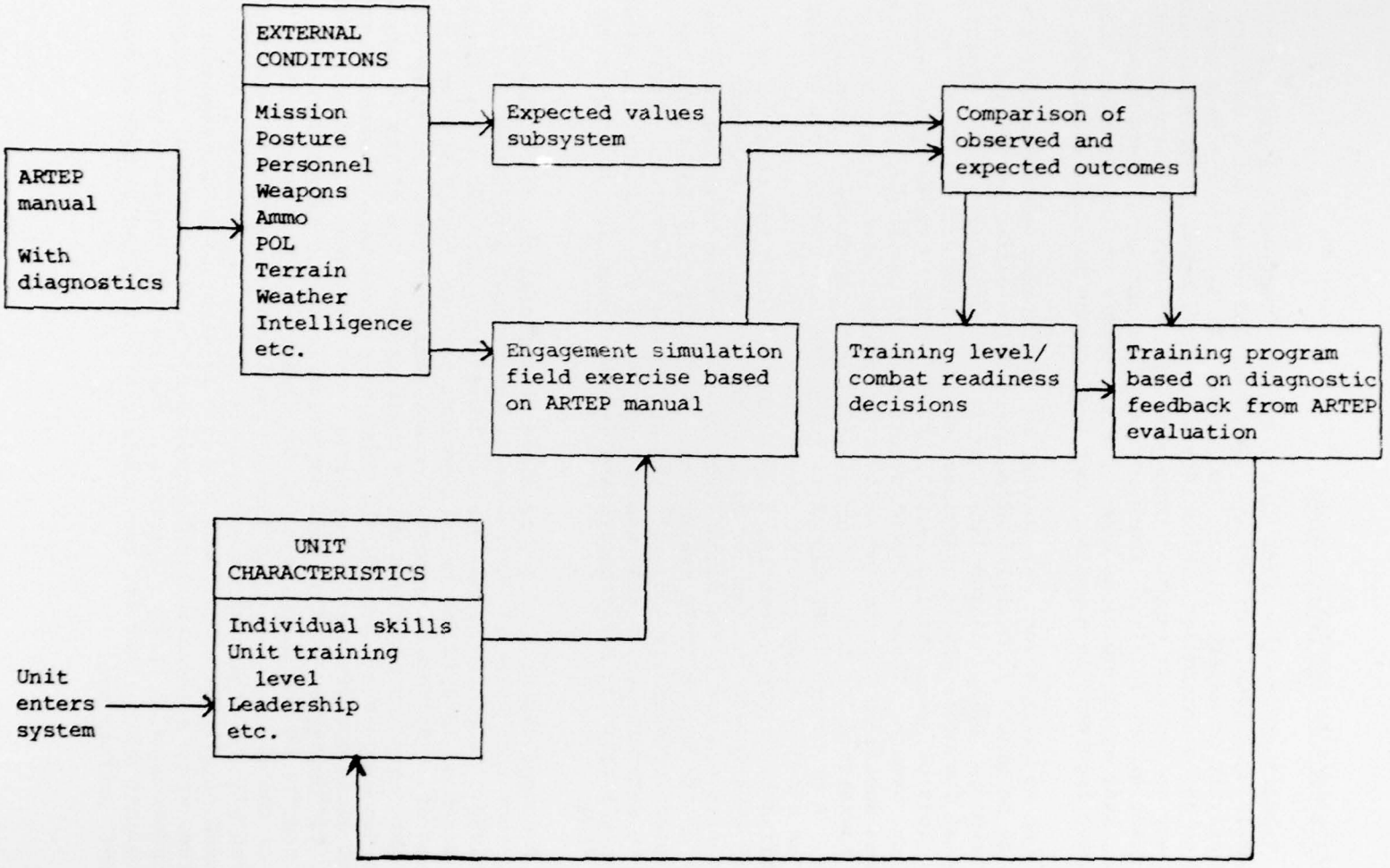


Figure 2. COTEAM evaluation system.

## Modifications to the ARTEP Manual

Traditionally, the ARTEP manual and the front-end analysis of behavioral objectives, performance variables, and measurements have relied heavily on expert military judgments. At ARI, efforts have been made to use standardized, scientific procedures based on empirical data, as a way to increase experts' consensus and as a means of testing and verifying expert opinion. These methods also provide a basis for reducing many expert opinions down to a manageable set of variables that are most important in assessing unit performance in field exercises.

One research effort has focused on identifying variables that appear to be useful in discriminating among units differing in tactical proficiency. Using a large data base from combined arms field exercises, critical incidents within exercises have been identified, as well as the causes or precipitating factors of particularly damaging or helpful tactical events. These critical events include particularly long delays between acquiring targets and delivering indirect fire, units that expose themselves for long periods of time, and breakdowns in communications. A prototype ARTEP manual is being developed with a set of diagnostics based on these critical incidents. These diagnostics are "enabling behaviors"; that is, a unit that performs the behavior is more likely to complete its task or mission than a unit that does not. Evaluators also can use these diagnostics to help develop training programs based on the unit's ARTEP evaluation. By noting which tasks were not completed successfully and, with the aid of the diagnostics, tracing back to determine why a task was not completed, the evaluator can assess the unit's training deficiencies and develop a training program to correct them.

A second research effort is aimed at defining the major dimensions or factors that military judges use to assess unit performance in field exercises. Multidimensional scaling (MDS) techniques are being explored as a means of identifying these important factors. Using written narratives of 15 different armor/anti-armor field exercises, military officers were asked to rate each unit's performances. One of the 15 narratives was used as a "target"; the other narratives were compared to the target along certain specific criteria. For instance, the officers were asked to "judge how similar each narrative is to the target narrative with respect to the performance of the combat unit in the narratives." Each of the 15 narratives was used as the target; comparisons were made between all the other narratives and the target. A similarity matrix composed of all the comparisons was used as input to an MDS computer program, which mathematically determined how many factors, or dimensions, the judges used in their comparisons. The results yielded a three-dimensional space; that is, the judges used only three factors to evaluate unit performance.

The next step in this research is to define or label these dimensions. To do this, a list of possible dimension-defining attributes is composed, a new set of military judges then ranks the narratives with respect to how much each narrative is characterized by the attributes, and these comparisons are used as input to a second MDS analysis. The set of three attributes that defines a three-dimensional space most similar to the original is the set of factors that military judges consider to be important in assessing unit performance in field exercises.

A third area in which the current ARTEP is being improved is in the training given to the evaluation team. A detailed program of instruction (POI) (Havron, McCullough, McFarling, & Wanschura, 1979) for evaluators is being developed and field tested. The POI teaches the evaluators how to design and set up field exercises, obtain observations, assess unit performance, and provide feedback to the units. The guide includes the rationale for the development of the POI, which stresses the roles and importance of the evaluators; a command planning module, which presents the planning necessary to conduct an evaluator training session; and the POI itself.

The POI provides structured guidance for the evaluators in all aspects of their duties, including each evaluator's role and the required coordination of roles, methods for controlling field exercises, use of pyrotechnic simulators, terrain reconnaissance for exercise lanes, data analysis, report preparation, and postexercise critiques. The POI constitutes the first significant attempt to develop guides for persons who evaluate unit performance in field exercises.

## Engagement Simulation Field Exercise Test Bed

Although some engagement simulation (ES) technology has been fielded by the Army, most current ARTEP field exercises do not use objective methods for simulating and assessing casualties. Some question exists, therefore, of whether the behavior displayed in these exercises represents true combat performance. The evolution of engagement simulation from SCOPES and REALTRAIN (TC 71-5) to the Multiple Integrated Laser Engagement System (MILES) has increased dramatically the realism of the combat environment and the objectivity of casualty assessment. The National Training Center (NTC) will move this evolution a step farther by providing a computer-controlled, instrumented range with unique weapon signatures for each weapon system in field exercises up to battalion size.

Engagement simulation exercises are superior to the ARTEP field exercises in promoting tactical behaviors, terrain appreciation, cover, and concealment (Havron, McFarling, Hill, & Wanschura, 1979b; Scott, Meliza et al., 1979; Banks et al., 1977; Meliza et al., 1979; Scott, Banks et al., 1979). Engagement simulation provides immediate and valid feedback to individuals and weapon crews and enhances troop motivation and presumably readiness to learn (Sulzen & Bleda, 1979). The after action review (AAR) gives the unit, weapon crews, and individual soldiers

an opportunity to learn from their mistakes and benefit from the experiences of the other participants.

In addition to providing a realistic combat environment, ES exercises allow ample opportunities for collection of objective data on unit performance. In March 1978, ARI produced and field tested at Fort Carson, Colo., a low-cost tactical operations measurement system that is computer-supported (Epstein, 1978). The system includes methods and measurement forms for recording tactical processes, position location data, maneuver routes, and tactical outcomes without instrumented data collection. The data are reduced and coded using machine-scorable optical scanning forms and are organized by the computer to provide a coherent data base suitable for a wide variety of analyses. The NTC will improve this data collection effort by using instrumentation that automatically records high-resolution position location, time, and engagement data.

In an effort to implement ES in the field, ARI has conducted an ongoing research program designed to incorporate the ES methodology into the ARTEP framework. This incorporation may not be a trivial, mechanical problem. ARTEP currently consists almost entirely of procedural statements of tasks, conditions, and standards for one side in a two-sided game; that is, it is formatted as a procedural checklist. ES, however, was designed to improve training by increasing realism, particularly with respect to casualty assessment. The problem is to combine the high-fidelity outcome data available with ES with the procedural formats related to critical processes included in ARTEP.

The modified ARTEP discussed above attempts to relate the high-fidelity casualty data obtained using ES methods to specific ARTEP processes and more global task statements. For example, REALTRAIN data from the combined arms test at Fort Carson are being analyzed to establish their connection with ARTEP-type task statements. What has evolved to date is an experimental ARTEP format (Mirabella, 1977; Sulzen & Root, 1976) including mission-derived tasks and conditions supported by process and product measures of performance. This experimental format provides initial attempts to reduce limitations on performance measures and casualty assessment characteristic of the original ARTEP model.

Although the modified ARTEP relates objective ES outcome data to ARTEP tasks and processes, the standards problem has not been addressed except in a norm-referenced sense; for example, what is the performance level of Team A relative to some earlier point in training, or relative to Team B? In the current operational system, the ARTEP evaluators carry around in their heads both the scales of performance and a set of performance criteria for applying these scales. Current ARTEPs do not provide an appropriate set of criteria. More often than not, ARTEP standards are either procedural statements or undefined cut points; e.g., "casualties shall not be excessive." Also, the current standards are not suitable for two-sided interactive behavior. With regard to

scales of performance, current ARTEPs provide little if any guidance. ES operationalizes some of the scales of performance, although it does not, in and of itself, provide the criteria for interpreting the performance data; a new model feature is required.

## Expected Values Subsystem

The expected values subsystem of the COTEAM evaluation system is designed to provide performance criteria, standards, or benchmarks against which ES field exercise outcomes can be compared. One objective of the subsystem is to provide a set of systematic methods for defining specific behavioral and attrition expected values for ES exercises based on values of external variables in a specific exercise and the assumption of combat-ready opposing forces. The evaluation staff can use these expected values in making evaluation decisions regarding unit performance and in training diagnosis.

To systematize and standardize the evaluation of unit performance in ES exercises, performance benchmarks or standards must be defined. The dynamics of two-sided field exercises do not permit exact, deterministic standards, however. The standards must be in the form of probability distributions, tolerance limits, or principle-derived sets of correct solutions to tactical problems. To establish one or more of these types of standards, large amounts of ES outcome data must be obtained so that the characteristics of the distributions of ES outcomes can be determined. Because replication of field exercises is difficult and costly, the distribution of ES outcomes cannot be generated in field exercises. As part of the COTEAM research program, therefore, inexpensive simulations of ES exercises are being developed to provide large amounts of valid ES outcome data.

The concept of situation-specific forecasting is being used to develop an ES outcome data base from which the characteristics of the distributions of ES outcomes can be determined. Situation-specific (Root et al., 1978) means that the forecasting procedures replicate the particular field exercise conditions as closely as possible; a forecasting exercise uses the same force ratios, weapons mix, terrain, weather conditions, and missions as the corresponding field exercise. Given a valid data base of ES outcomes, expectations about tactical processes and casualties can be derived for units participating in ES field exercises. The methods being developed or adapted for generating the data base include (a) military experts' DELPHI, (b) board war games, and (c) computerized ES models.

## DELPHI

The DELPHI technique is designed to exploit and enhance experts' judgments in analysis, evaluation, and forecasting. In its simplest form, the DELPHI technique is a carefully designed series of individual

interrogations (usually written questionnaires) coupled with information and opinion feedback.

For example, suppose a panel of military experts is convened to estimate the number of casualties a small combat unit would sustain during a specific mission. Each panel member responds individually with an initial estimate. The person in charge of the panel collects the data and computes the median and the interquartile range (the interval containing the middle 50% of the responses). Each panelist receives the results and is asked to make a new estimate. In addition, if the panelists' estimates are outside the interquartile range, panelists are asked to indicate why their responses were different from the majority judgment. Thus, panelists holding extreme views are forced either to defend their positions with explicit reasons or to move toward the majority opinion. Results of this second iteration are tabulated and given to the panelists along with a summary of reasons presented by those who hold extreme positions. This process continues for four or five rounds of voting. The median of the final set of responses is then assumed to approximate the group judgment, and the range of responses may be presented, representing an ordered, weighted series of judgments, i.e., a set of answers with associated priorities.

A variation of the DELPHI technique that may have particular use in COTEAM combines DELPHI with scaled or comparative judgments across a set of stimuli. (See Wheaton and Mirabella, 1972, for an illustrative application in training effectiveness research.) In this case, empirical data on reference training units might be used as anchors for judgments of other assumed training levels.

The DELPHI technique typically leads to a convergence of opinion. Other benefits gained from using DELPHI are that assumptions are made explicit, a broad range of alternatives is produced, and judges are sensitized to the complexities and interactions that influence alternative outcomes. The success of the DELPHI technique, however, depends on several factors--the "expertness" of the panelists, the type and amount of feedback provided, and the quality of the questionnaires used.

A pilot study to determine whether military personnel could make the judgments required for the DELPHI procedure was conducted in 1977 at Fort Ord, Calif., as part of a REALTRAIN rifle squad validation test (Mirabella, 1977). Exercise participants were asked how they would expect infantry squads to perform on a number of variables pertinent to a movement to contact mission, assuming four levels of training: BCT; Level 2 of infantry ARTEP; Level 2, plus 3 or more days of SCOPES training; and combat experienced. Forecasts were made for a set of process and product variables. Results suggested that military personnel can describe differences in expected performance as a function of hypothesized level of training and that expected values form a consistent ordinal scale across forecasters.

Board Games

A second method of producing accurate forecasts was explored during the armor Combined Arms Test (CATEST) at Fort Carson, Colo., from January to April 1978 (Medlin, 1979a). Using scenarios identical to those used during the actual field exercises (i.e., force mix, OPORD, weather, terrain, etc.), data were collected using the Fort Carson Forecasting Game, a board war game. The game was developed specifically for the Fort Carson exercises. A 1:3,125 pictomap of the exercise lanes served as the game board. A hexagonal grid overlay, with each hex corresponding to 50 m of terrain, was placed over the map to help standardize movement rates, detection distances, and range of weapon effectiveness. In the two-player version of the game, each player maneuvers his forces on a separate board, out of sight of the other player. Play is controlled by a single controller, who insures observance of the rules, keeps exercise time moving, delivers indirect fire, provides detections, and assesses casualties. Although the controller may seem to have considerable power, most of his functions are clearly and precisely explicated in the rules. The only subjective decision involves detections; if the controller is unbiased and has had some experience with the actual exercise terrain, his decisions on detections can be fair, accurate, and easy to make.

Results of the study indicate a few small differences between forecast and field exercise data; in general, however, the data from the two different sources are quite comparable. Only two differences of any magnitude were encountered--the greater casualty-inflicting ability of the tank in the forecasting exercises and the greater lethality of artillery in the field exercises. These discrepancies do not seem to be related to the use of different skills in the field and on the game board. Rather, they seem to be due mainly to slight differences in the way the ES casualty rules were enforced in the field and on the game board.

A second study was conducted to evaluate the validity of board war gaming as a forecasting technique to determine performance benchmarks (Medlin, 1979b). Using data from the Combined Arms Test at Fort Carson for March 1978 and from the Fort Carson Forecasting Game, military judges were asked to distinguish between field exercise data and forecast data. Judgments were made on maps of exercise maneuver routes and tables summarizing data on the casualties suffered and the weapon system which inflicted each casualty. The military judges were not able to distinguish between field and forecast maneuver routes, and they tended to classify forecast casualty data as field exercise casualty data. Game board exercises, therefore, generate data similar enough to field exercise data for use in determining characteristics of the distribution of ES outcomes. In turn, these data can be used to define performance benchmarks or standards for units participating in ES field exercises.

## Computer Simulations

Ultimately, a computer simulation can be used to generate ES outcome data. Input parameters can be varied to assess the effects of external conditions and/or unit characteristics on field exercises. To develop the algorithms necessary for a computer simulation of ES exercises, the nature of the exercises, the processes involved in reaching the final outcomes, and the relationships among the variables affecting the exercises must be understood much better than at present. An exploratory effort at building a computer simulation to generate a computerized data base is now in progress. The simulation is designed to generate hypothetical casualty effects as a function of training level.

## Summary of Expected Value Generation

All of the above methods for expectation generation may be thought of as combat simulations, or theoretical models of combat. The methods must be situation-specific, replicating the field exercise battlefield as closely as possible. Convergent and empirical validity are established for the models if the expectations generated by them agree with each other and with the observed values from the field validation exercises, using units at assumed levels of proficiency (for example, "combat-ready").

If the expectations and observations do not agree, the expectation generation methodology is not necessarily deficient. One or both of the field exercise units may not be at the assumed level of training. This confounding of possible explanations can be minimized by using the leaders of the field exercise units to generate expectations about their own field exercises; that is, by having the same leaders forecast outcomes and conduct identical field exercises in which outcomes are recorded.

Because of the probabilistic relationship between behavior and attrition, and because of measurement error, discrepancies between expected and observed values for these two major classes of combat dependent variables will not always be consistent across replications of the same evaluation exercise. However, large divergence from expected values for either class of variables should warrant additional substantiating analyses, a reassessment of the expected-values generation methodology, or additional replications of the evaluation exercise. The value of the foregoing approach is not that it immediately resolves ambiguities associated with evaluating combat units; rather, the value of the approach is that it provides a systematic and scientific framework linking combat theory and combat unit evaluation. With repeated application, the framework will help resolve ambiguities associated with both combat theory, including doctrine, and combat unit evaluation.

Comparison Subsystem for Training Diagnosis

In addition to the diagnostics listed in the modified ARTEP and the ARTEP evaluators' POI, the COTEAM system introduces new techniques for assessing training deficiencies and proficiencies. The approach follows the research methodology for model testing and building outlined by Rapoport (1975). After methods for generating expected values have been validated, the expectations are used as "ideal," optimal, or baseline performance, and discrepancies between observed and expected performance are explored. It is assumed that discrepancies will be neither so large nor so unsystematic as to make the comparison meaningless or useless. If systematic discrepancies are found, they may be interpreted in terms of unit characteristics, external conditions, doctrine, or serendipitous events. If proper control is exercised, the interpretations may rest solely on unit characteristics and, in particular, on the training level of the unit. If the unit performs better than expected on some task, then it is proficient in that area. If the unit performs worse than expected, it has a deficiency that can be addressed in subsequent training.

In the initial expectation generation process, it is assumed that both units are combat-ready. This assumption makes it possible to obtain an "ideal" or optimal performance reference point. For example, suppose that a reliable discrepancy has been observed between the expected value and the observed value for attrition in a two-sided (Blue versus Red), free-play simulated combat exercise. What inferences about the training level of the Blue and Red forces can be made? Is Blue attrition lower than expected because Blue training is suprastandard or because Red training is substandard or some combination of the two?

To make inferences about the training level of both Blue and Red based on relative attrition, some reference points or baselines are needed. A minimum set of reference points are expected values for attrition under the following conditions: (a) Blue trained but Red not trained, (b) Red trained but Blue not trained, and (c) neither Blue nor Red trained. These additional expected values for attrition under these three conditions provide anchor points on a scale that can be used to interpret observed values of attrition for the Blue and Red forces and to relate observed attrition to training level. Additional reference points may be generated by representing assumed Blue and Red training levels with other than extreme parameter values. A similar set of reference points may be generated for quantifiable behavioral dimensions.

Judging unit performance on the basis of a comparison between what is expected of a unit and what it actually does is an attractively simple idea. The comparison provides the framework needed to evaluate units in a context broader than a specific exercise or series of exercises, yet it can be made sensitive to the particular conditions under which a unit is observed. Depending on the purpose of a particular

evaluation exercise, the comparison process can address specific training diagnostic questions, provide data for training management comparable to grade-equivalent scores, answer doctrinal questions, or indicate readiness for combat.

## SUMMARY

The Combat Operations Training Effectiveness Analysis Model (COTEAM) is an evaluation system for combat unit performance that systematically addresses the weaknesses inherent in the current ARTEP. ARI developed the model and is conducting research on all aspects of the system. Using the ARTEP as a starting point, the COTEAM model proposes a modified ARTEP manual that includes task/subtask diagnostics that facilitate the evaluation and training feedback processes and an evaluator program of instruction (POI) that teaches evaluators roles, duties, and how to conduct a field exercise. Furthermore, the task/subtasks listed in the manual are being scientifically and systematically analyzed to determine the critical events that must occur for a unit to perform its mission.

The rest of the COTEAM evaluation system is driven by the modified ARTEP manual. The evaluation environment is defined by the modified ARTEP manual (mission, posture, personnel, weapons, etc.) and the field conditions (weather, terrain, time of day, etc.). The unit to be evaluated enters this environment with certain unit characteristics (individual skills, unit training level, leadership, etc.). A realistic combat environment should be provided to assess the combat unit's performance on the ARTEP tasks/subtasks. Engagement simulation (ES) is a two-sided, free-play, tactical maneuver/field exercise that allows immediate and realistic casualty assessment. ES field exercises provide a realistic combat environment in which combat units can be evaluated. (Although a high-fidelity combat environment maximizes the usefulness of COTEAM, the model can be applied where high-fidelity technology is not available if suitable methods are used to generate expectations.)

The expected values subsystem of COTEAM is a means of evaluating performance in tactical field exercises. Given the external conditions as defined by the ARTEP manual, the field environment, and the ES exercise rules, expected values or expectations are generated for the process and product outcomes of the field exercises. These expected values provide a baseline, benchmark, or standard with which observed unit performance can be compared. Considerable research has been directed at the expected values subsystem of the COTEAM model. The DELPHI technique, board war gaming, and computer simulations are being developed as methods of generating expectations. Although the feasibility of the DELPHI technique and computer simulations is still being explored, board war gaming has been established as a means of generating expected values for process and product outcomes extremely similar to those observed in field exercises.

A comparison of the expected and observed outcomes facilitates evaluation of unit performance and decisions concerning training level and/or combat readiness. This comparison process, in conjunction with the ARTEP manual diagnostics and the evaluator training provided in the POI, provides information for feedback to the unit, particularly feedback concerning training deficiencies and proficiencies. This feedback can be used to structure the unit's training programs.

The COTEAM evaluation system is one of the models being developed as part of ARI's research on unit evaluation. The system introduces a realistic simulated combat environment in which units perform tactical operations and in which objective data can be obtained, specific procedures for determining standards against which unit performance can be compared, and techniques for assessing training level, combat readiness, and training deficiencies can be refined. Research is being conducted on all aspects of the model, and modifications to COTEAM will incorporate the results of these efforts. The ultimate goal of this research is to develop a criterion-referenced system for evaluating unit tactical performance.

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